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SOME FURTHER REMARKS ON TOBACCO CULTIVATION FOR NICOTINE

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SOME FURTHER REMARKS ON TOBACCO CULTIVATION FOR NICOTINE.

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INTRODUCTORY.

During the past two or three years attention has been devoted to the utilization of tobacco for the manufacture of dips and sprays, and some articles have been published in the *Journal* on this subject.

As a result of work in this line, attention has been directed to the growing of *Nicotiana rustica* for this purpose, and papers have been produced by Juritz (2) and Oosthuizen (4). As an introductory to the latter paper, some remarks appeared in the same *Journal* which, on account of their economic interest, should be perused by those who are or are likely to be interested in this subject.

A further article has appeared in November number of the *Journal* by Koch (3), which adds further information to the subject of growing *N. rustica*, and is of interest to the grower or the prospective grower.

Rumours of heavy monetary returns per acre and of high nicotine percentage in the plant much above those given in the above papers gave rise to the desire of ascertaining more about the subject. If profits as high as £50 or even £25 sterling per acre from one or several cuttings could be obtained, they will give a considerable impetus to the industry—conditional upon there being a satisfactory market for the product.

On the other hand, if through some circumstance or other these rumours were incorrect, although given with every good intention, they should be challenged and instances sought in which such profits could be proved and the reasons for them made plain to the farming community, if possible.

The work done in this laboratory over the past year has enabled certain conclusions to be arrived at from experiments on the farm here and from samples grown at Rustenburg by one of the writers; also from samples from outside sources in the Cape Province and in the Rustenburg area. These results are given in two sections in this paper.

SECTION I.

THE PLANT AS A WHOLE AND ITS COMPONENT PARTS.

The Yield per Acre.

Data on the green as well as dry weights of tobacco obtainable per acre are as yet very meagre. Oosthuizen (4) has given the yield from lightly and more heavily manured plots at various distances of planting obtained in a one-year trial. His results are reproduced in Table 1.

In the present investigation, up to 7,000 lb. of the air-dry product were obtained per acre, the yield being calculated from the dry weights of six or more representative plants with the aid of the tables given by L. H. Bailey (1) (p. 120).

The plants were grown in rows three feet apart, with a distance of twelve inches between the plants. The figures calculated from other samples received here were 3,400 lb., 4,600 lb., 6,200 lb., and 7,400 lb. air-dry material per acre.

The yield per acre will naturally depend upon the soil, climate, and other conditions.

On a reasonably fertile soil and under normal conditions of rainfall, stand, etc., the prospective grower should be able to obtain from 1,000 to 4,000 lb. of air-dry material per acre for the first cutting and probably as much from subsequent cuttings if these are obtainable.

Table 1.—Yield of tobacco per acre grown in rows three feet apart, as given by Oosthuizen.

Treatment.	Plants 12 in. Apart.	Plants 18 in. Apart.	Plants 30 in. Apart.
	lb.	lb.	lb.
Lightly manured	2,021	1,623	--
Fairly heavily manured	2,656	2.213	1,888

The Moisture-content of Green and Air-dry Tobacco.

Juritz (2) speaks of the dry matter in the green plant, calculated on the air-dry basis, as being nearly 30 per cent., and the moisture-content of the air-dry plant as being from 12 to 15 per cent.

The writers have found the dry matter in the green plant to be from 12 to 18 per cent., calculated on the air-dry basis according to the age and maturity of the plants. The moisture in the air-dry matter varied from 6 to 7 per cent. in the normally dry atmosphere of Potchefstroom, and, unless otherwise stated, all data presented in this paper are calculated on the basis of 6 to 7 per cent. moisture in the air-dry material.

The green weights, air-dry weights, percentage of air-dry matter in the green plant, and percentages of the component parts of eight plants grown under identical conditions and cut eighty days after planting are given in Table 2.

It would be well to remember that when tobacco contains only 6 to 7 per cent. of moisture, it is brittle and cannot be handled and baled without

breaking or crumbling to bits. Tobacco must contain at least 9 per cent., and usually from 10 to 13 per cent., of moisture before it is in ease, i.e. before it can be handled, stripped, or baled without breaking the leaf. Yet it is true that even if the tobacco when baled contain 10 to 15 per cent. of moisture it may dry out in the bale after a time until the moisture-content is from 7 to 8 per cent. only.

The latitude of moisture is very considerable, varying according to the humidity. A moist day, either through mist or rain, will soften up the leaf, as is well known, but it may not be so well known that the moisture-increment may be as much as 8 per cent. in twelve hours, bringing the moisture-content in total, for the conditions here, up to 14 or 16 per cent. This variation may be the cause of friction between buyer in a moist climate and the grower in a drier area on account of the lowering of the nicotine-content per unit weight of material. In assizing the value of a crop it would be wise to take this factor into account.

Table 2.—Showing green and air-dry weights, percentages of component parts and percentage of dry matter in eight plants grown under identical conditions at the Potchefstroom School of Agriculture.

No. of Plant.	1.	2.	3.	4.	5.	6.	7.	8.
Green weight of plant in pounds.........	2·3	2·3	2·85	3·12	2·87	2·44	2·45	2·27
Per cent., air-dry matter............	16·3	16·2	18·0	16·6	15·4	16·9	13·6	14·0
Per cent., moisture in air-dry matter....	6·82	6·47	7·41	6·73	5·87	6·14	6·52	6·36
Per cent., leaf......	43·4	50·4	50·0	46·8	46·3	44·3	48·4	46·4
Per cent., stalk.....	29·5	35·6	34·2	36·2	40·0	34·7	33·2	36·0
Per cent., pod......	27·1	14·0	15·8	17·0	13·7	—	18·4	17·6

The Nicotine-content of the Plant.

The nicotine-content of the plant taken as a whole is comparatively low, owing, no doubt, to the low percentage of leaf present. In the work which was carried out previously, the nicotine in *N. rustica* ranged from 1 to 3·5 per cent., with an average of 2·12 per cent. (4). These results were obtained when the plants had passed the highest nicotine content-stage.

In the present experiment the nicotine-content was found to vary from 2·79 to 4·79 per cent. at the stage with the maximum content, as is evident from Table 11, Section II.

For convenience, the averages of the controls given in the above table in Section II are plotted in Figure 1 for topped and untopped plants at various stages of growth.

Other samples forwarded to this laboratory have given very divergent results. Seven of these are appended below in Table 3.

It is evident from these figures that the nicotine-content of the plants examined by the writers does not usually exceed 4·5 per cent., and the average is certainly below this figure.

For convenience, the plant may be divided into four parts, viz. :—

1. *The Leaf.*—Consisting of the leaf proper with the stem or petiole by which it is attached to the stalk.
2. *The Stalk.*—Which embraces the main stem and shoots up to the joints of the leaves and pods.
3. *The Pod.*—Which consists of seed and the flower or pod with the stem which joins it to the stalk as defined above.
4. *The Root.*—The portion below the ground level.

The Leaf.—In the majority of cases examined the leaf occupies from 45 to 55 per cent. of the air-dry plant. It contains by far the major portion of the nicotine present in the plant, and the percentage of leaf is therefore of considerable interest since this will influence the monetary return from a crop more than any other factor.

The figures furnished by Juritz for *N. rustica* (2) are reproduced below, being taken on the moisture-free basis.

Young plants 2 to 3 inches high just transplanted	Contained 0·91 per cent. nicotine in leaf.
Six weeks later, plants are 2 feet high..	Contained 2·44 per cent. nicotine in leaf.
Two weeks later, plants are dried....	Contained 3·37 per cent. nicotine in leaf.
At a later date, plants partially dried in laboratory (air-dry basis)	Contained 11·20 per cent. nicotine in leaf
Leaves cured in Elsenburg shed........	Contained 6·90 per cent. nicotine in leaf.

In a former paper (4) one of the writers obtained the following percentages for the nicotine-content of the leaf calculated on a moisture-free basis, viz. : Maximum, 5·25 per cent. ; minimum, 4·17 per cent. : and an average of 4·9 per cent. In the present study the figures furnished by the respective cuttings, from plots described in Section II, to which no fertilizer was applied, are given in Figure 1.

These results were obtained on nine plants in aggregate. To obtain some idea of the individual variation the following figures will serve, being the nicotine-content of leaves from eight individual plants topped twice during growth and cut eighty days after planting: 7·29 per cent., 7·82 per cent., 7·41 per cent., 6·97 per cent., 5·40 per cent., 5·71 per cent., 8·2 per cent., and 7·62 per cent. (on moisture-free basis).

The figure of 11·20 per cent. given by Juritz (2) has not been obtained in this laboratory, the highest results exceeding 8 per cent., but falling short of 9 per cent.

From the graphs of Figure 1 it appears that the nicotine-content of the leaf increases steadily and continuously up to a maximum, after which it falls away rather rapidly. This increase is not found in the stem or pod, as will appear later. This is in accordance with former findings. The stage of maximum nicotine-content will no doubt vary with climatic conditions, notably rainfall and temperature, and may very probably be connected with the setting of the seed and the maturing of the reproductive parts of the plant. The more conducive the climate is to rapid maturing of the plant and the longer the growing season, the larger will be the number of cuttings at the above stage, thus giving a maximum nicotine-content.

There is, in the writers' opinion, a distinct indication as to when the nicotine-content is around its highest point. This stage is determined by doubling up the leaf between finger and thumb, when a sharp crack will result. Up to this point the leaf exhibits flexibility to such pressure. A second indication, which is not so easily perceived, but can be seen by careful observation, is in

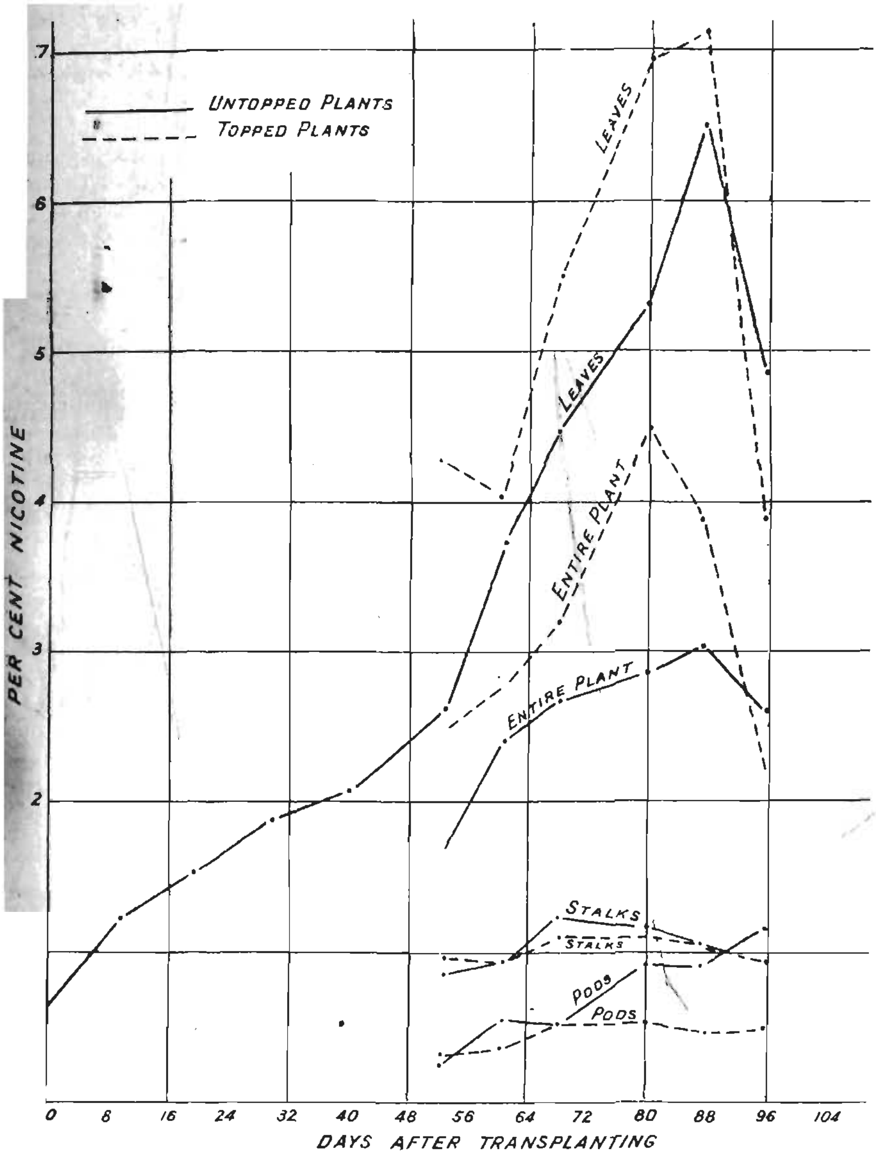

FIG. 1.—The nicotine-content, at various stages of growth, of the entire plant and its component parts for plants topped twice and otherwise similarly treated plants left untopped. The analyses for the component parts were obtained from the same samples as that for the "entire plant."

the appearance of the foliage and the setting of the seed and the formation of the pods in plants which have their pods. The leaf appears to be about to yellow off very slightly, the full green giving rise to a lighter and yellower tone. The tops show the yellowing in a trifle more advanced degree in the more fully matured pods, and in nearly all pods the seeds are browning up and in some cases almost ripe.

The point of maximum nicotine-content in pounds per acre is consistent with the maximum nicotine-content of the leaf.

Increased leaf production per plant is obviously desirable, but this falls under the scope of the plant breeder, the question being whether it would be advisable to breed up from the present varieties by selection or to cross with the most suitable variety of *N. tabacum* the cultivated species of our tobacco-fields.

A cross obtained by Oosthuizen at the Rustenburg station gave a plant which when air-dried analysed as follows :—

Percentage of leaf : 59·5 per cent., containing 7·8 per cent nicotine.
Percentage of stalk : 40·5 per cent., containing 1·18 per cent. nicotine.

The growth resembled that of *N. tabacum*.

The seed of this first-generation cross gave rise to a type similar to *N. tabacum*, but its nicotine-content is unknown to us.

By reason of this, and as it appears that there is a considerable variation in the nicotine-content of individual plants, it would probably be better to breed up a high nicotine-yielding strain by selection, as has been done in the case of the high protein-content with maize.

The Stalk.—The stem, or stalk as the writers have designated it for purposes of discussion, comprises from 25 to 45 per cent. of the air-dry plant. In only a few instances, however, did the figures vary from below 25 to above 45 per cent. It contains very considerable less nicotine than the leaf. Juritz quotes the content as being from 0·67 to 0·79 per cent. for the two analyses. In a former paper (4) it was found, as a result of eleven different analyses, that the nicotine varied from 0·78 to 1·32 per cent., with an average of 1·13 per cent. on the air-dry basis.

Table 3.—The nicotine-content and the percentage composition of tobacco plants obtained from various localities.

Origin.	Composition.			Per Cent. Nicotine in Plant.
	Leaves.	Stalk.	Pods.	
	Per Cent.	Per Cent.	Per Cent.	Per Cent.
1. Cape Province	43·8	30·4	25·8	1·64
2. ,,	23·4	27·6	49·0	1·78
3. ,,	58·6	23·4	18·0	4·47
4. Rustenburg	46·0	44·0	10·0	3·91
5. ,,	44·2	37·4	18·2	4·70
6. Potchefstroom	42·0	27·0	31·0	3·01
7. ,,	48·1	34·9	17·0	3·52

In the present investigation, see Figure 1 and Table 9, Section II, the nicotine, calculated on the air-dry basis, varied from 0·76 to 1·20 per cent. in the stalk of *N. rustica*, with an average of approximately 1 per cent. This figure is very nearly the same as that found in the stalk of *N. tabacum* grown at

his station, the average for numerous determinations on several varieties being 1·19 per cent.

The nicotine in the stalk is apparently more stationary than in the pod, little rise or fall being noted during the course of growth. Topping does not affect the nicotine in this fraction.

The Pod.—The pod-content varied from 7 to 50 per cent. of the air-dry plant, but in the majority of cases only between 18 and 25 per cent. in the untopped plants. The question of topping will be discussed later. In this fraction the nicotine-content increases as the plant matures, as will be apparent from the graphs of Figure 1.

Juritz quotes 0·43 and 0·79 per cent. for two analyses, and one of the writers obtained from 0·65 and 1·39 per cent., with an average of 0·95 per cent. for a series of analyses on mature plants (4).

In Figure 1, the averages of the analyses of the tops at different stage of growth obtained for the control plots, described in Section II and Table 9, are reproduced graphically. In the "topped" series the plants were topped in the field immediately before the first and again before the fourth cutting. The tops were in each case collected from the plants before drying and dried separately. In the untopped series the plants were dried without removing any growth either in the field or after cutting. Further notes will be given under "Topping the Plants" below.

Six samples of seed which were carefully freed from all extraneous materials were examined. The results are summarized in Table 4.

Table 4.—The nicotine-content of seed of N. rustica *obtained from different sources.*

Origin of Sample.	Per Cent. Nicotine.
Cape Province..........................	0·041
,, ...	0·045
Potchefstroom..........................	0·037
,, ...	0·030
Rustenburg..........................	0·061
,, ...	0·047

Table 5.—Influence of topping on nicotine-content of N. rustica.

Treatment.	Per Cent. Nicotine.		Dry Weight per Acre.	Nicotine Per Acre.
	In Leaf.	In Plant.		
			lb.	lb.
Topped for five consecutive weeks	7·92	5·25	8,191	430
Topped twice—five weeks and two weeks before cutting.....	7·42	4·58	7,600	348
Topped once before cutting.....	7·30	4·30	7,419	319
Untopped....................	6·46	3·97	6,860	273·3

The Root.—This has seldom been analysed in this laboratory. On the basis of such analyses as have been made an average of 0·51 per cent. nicotine with a maximum of 0·71 per cent. and a minimum of 0·29 per cent. may be reported.

THE TOPPING OF "N. RUSTICA."

The beneficial effects of topping the plants on the nicotine-content is apparent from Figure 1. Special attention has been given to this point in this series of experiments.

The area that one man is capable of topping in a day will naturally vary somewhat with the individual and the growth. At this institution it was found that by careful topping, no more than one-third of an acre could be done per day. In topping, the flowery growth was sought for and removed so as to leave the new leafy growth. There is need for care to retain as much of the young leaves on the plant as possible and yet to remove all of the floral part.

The persistent tendency of the plants to seed is evident, and each topping is accompanied by a successive new growth. The mature leaf, too, seems to retain its full colour longer.*

In Table 5 the results of an experiment with plants topped at different times of their growth period are compared as regards nicotine-content with plants treated identically but not topped.

It is clear that the effect of topping is threefold. It increases the nicotine-content in the leaf, probably due to no transmission of the nitrogenous compounds to the flowering parts. It increases the weight of the plant by inducing the plant to continue its efforts to seed production and thereby producing more green leaves. It prevents the decomposition of the nicotine in the leaf during curing or drying.

That a change takes place in the nicotine-content when the pods are not removed, even after the plant is cut and being dried, is shown by the figures of of Table 6. These were obtained from plants completely stripped of all flowers and pods, and plants dried without removing the pods.

THE RATOONING OF "N. RUSTICA."

The strong tendency of the plant to send up new shoots on cutting and the subsequent growth which is similarly high in nicotine-content allows of the grower aiming at a second or even third crop and more if obtainable.

Oosthuizen (4) quotes figures from which it is plain that the nicotine-content of the second crop or cutting compares very well with that of the first.

Table 6.—The effect of the flowers and pods on the nicotine-content of the leaf after cutting the plants.

Treatment.	Percentage of Nicotine in Leaf.	
	Flowers Removed after Cutting.	No Flowers Removed after Cutting.
Topped twice during growth	5·67	5·38
Topped once during growth	5·72	5·47
Untopped	5·31	4·92

* Oosthuizen (4) remarks that by topping, the plants naturally send out more suckers, and it will pay the farmer to top at least twice and, if possible, more often. By doing this all the largest leaves will mature more or less at the same time, otherwise the largest leaves will be fully matured and begin to dry off, while the leaves higher up will still be practically green. By topping, therefore, a happy medium can be struck, and the plants can be harvested when most leaves are matured.

The analyses of plants of the first, second, and third cuttings received at this laboratory from various sources are given in Table 7.

The profits derivable from the second and third crops compare very favourably with that from the first.

The number of cuttings, their maximum nicotine-content, and their maturity will depend mainly on the length of the growing season, and the subsequent cuttings after the first may equal the latter in all respects. The possibility of obtaining the maximum yield of nicotine over one season may perhaps be realized better in cutting just before maturity since the longer period for the subsequent growth may give a third cutting, which may counterbalance and outweigh the loss in nicotine in the first two cuttings.

It is essential that some green growth be left on the plant at each cutting to ensure a ratoon crop. The plant does not generally throw up new shoots from a leafless base.

The Methods of Curing.

Oosthuizen (4) has already described a series of experiments on this question. He found that flue curing gave about 30 per cent. more nicotine in the product than air-drying, but doubted that the expense involved in flue curing would be covered by the extra returns. His results were obtained with *N. tabacum*.

Results with *N. rustica* in the present investigation are detailed below :—

	Percentage Nicotine in Leaf.	Percentage Nicotine in Stem.
Plant air-dried	3·66	0·7
Plant sun-dried	3·65	0·72
Plant green sweated and then air-dried	4·62	0·8
Plant flue cured	5·75	—
Leaves stripped from plant and then air-cured	4·0	—

In obtaining the material for these analyses, special precautions were taken to obtain representative samples. It appears from these figures, which on the whole confirm the findings of Oosthuizen, that flue curing gives the maximum nicotine-content in the product; stripping the leaves before drying gives a better yield of nicotine than drying the leaf on the stem. Drying the plants in the sun is probably not as good as when this is done in the shade. On the whole, green sweating seems to be the best method of treating the plant to obtain the maximum of returns considering the expense involved in flue curing.

It is plain that the tobacco plant is able to utilize the nicotine, which it has stored up during its natural growth, to supply energy for its metabolism when for any reason the food supply runs low, as in the case of cutting the plant. In order to obtain the maximum nicotine-content thus, the metabolism of the plant must be arrested at the stage of maximum nicotine-content as soon as possible after cutting. As mentioned above, green sweating seems to be the most economical way of accomplishing this.

Table 7.—Showing the relative weights of plants and nicotine to be derived from consecutive cuttings of N. rustica *for each cutting.*

Locality Received From.	Cutting.	Weight of Air-dry Plant.	Percentage of Nicotine in Leaf.	Percentage of Nicotine in Plant.
		Oz.		
Rustenburg District..............	First..........	13¾	5·84	3·82
	Second........	12	5·64	3·70
Cape Province..................	First..........	10	4·20	2·97
	Second........	11	5·00	3·01
	Third..........	9¼	3·98	2·56
Experiment Farm, Potchefstroom	First...........	9¼	6·8	3·97
	Second........	7½	5·4	3·82
	Third..........	6	5·9	3·60

SECTION II.

PART A.

INVESTIGATION ON THE EFFECT OF NITROGENOUS MANURES ON THE NICOTINE YIELD OF *N. RUSTICA.*

It has been generally assumed that the influence of nitrogenous fertilizers applied to tobacco is to produce a coarser growth and a greater amount of nicotine in the plant than would be found in plants grown on a similar soil to which no such additions were made.

To obtain some information on this point a series of plots of *N. rustica* was established at this station over the the season 1922–23. Some of the plots were treated with different nitrogenous fertilizers, each receiving an equivalent of 50 lb. of combined nitrogen, while the rest were left untreated and served as controls.

In addition to the fertilizer treatment, the plants on various plots were topped so that a comparison could be made both of the influence of the fertilizer applications and of topping on the nicotine-content of the plant.

As soon as the first flowers had formed, some plants from each plot were cut, and thereafter at different times during their growing period, weighed, dried, and divided into the component parts, each of which was weighed and analysed for nicotine. By this procedure the green and air-dry weights per acre for the whole plant and its component parts could be determined for each plot as well as the nicotine-content at different stages in the growth-cycle. No second "crop" was taken from any plant.

The Soil is a clayey loam from Andesite, admixed with some alluvial deposit and of good fertility.

The Rainfall.—During the period of growth the rainfall recorded was :—

In November 4·30 inches, which fell over fourteen days, with a maximum of 1·12 inch and a minimum of 0·02 inch ; in December 2·33 inches over ten days, maximum 1·57 inch and minimum 0·15 inch ; in January 4·68 inches over ten days, maximum 1·57 inch and minimum 0·15 inch ; in February no rain up to last cutting.

TREATMENT OF PLOTS AND OF PLANTS BEFORE CUTTING.

In Table 8 the treatment of the individual plots as well as that of the plants on each plot are summarized.

Table 8.—*Fertilizer treatment of plots and treatment of the plants.*

No. of Plot.	Fertilizer Treatment (per Acre).	Cultural Treatment.
1	Control—no fertilizer	Plants topped.
2	333 lb. nitrate of soda	Plants topped.
3	333 lb. nitrate of soda	Plants not topped.
4	Control—no fertilizer	Plants not topped.
5	250 lb. sulphate of ammonia	Plants topped.
6	250 lb. sulphate of ammonia	Plants not topped.
7	Control—no fertilizer	Plants topped.
8	277 lb. calcium nitrate	Plants topped.
9	277 lb. calcium nitrate	Plants not topped.
10	Control—no fertilizer	Plants not topped.
11	333 lb. nitrate of soda	Plants topped.

The plants were put out on 1st November and the fertilizer applied on 12th November.

The first topping was done fifty-three days after planting, just as the first flowers appeared, the second and last topping sixty-eight days after planting. Within this period there was a prolific development of more heads. Side shoots appeared towards the tops of the plants, and there was thus a notable production of more leaves. The extent to which this took place may be seen from Table 10 for the samples taken on 1st January, in which no less than 7 to 9 per cent. of tops were again present, and that only eight days after the former growth was removed.

The untopped plants on the other hand devoted their energy mainly towards the development of the existing flowers and pods, producing only a small amount of new growth. Their stems seemed to develop at a greater rate than those of the topped plants, where the new leaves were produced on new shoots.

Times of Cutting.

Plants were removed at the following times and stages of growth :—

On 23rd December, or fifty-three days after transplanting.—The plants were just in bloom. The first topping was done on this day and before the plants were cut. The topping was carried out as described in Section I of this paper. The topped plants for this analysis were thus completely devoid of of floral parts during drying.

On 1st January, or sixty-one days after transplanting.—On this date the plants were in full bloom, and some pods had already formed. Secondary shoots with immature buds had developed on the topped plants.

On 7th January, or sixty-eight days after planting.—The untopped plants still contained some flowers, but pods were well formed and filled out. The second and last topping was done on this day, the secondary shoots from the topped plants having formed well-developed tops already. The topped plants for this analysis were thus also devoid of tops during drying.

On 19th January, or eighty days after planting.—The plants of the untopped series had formed a considerable amount of tops in which seeds were already

setting, whereas those topped on 7th January had sent out fresh shoots and flowers.

On 27th January, or eighty-seven days after transplanting.—On the untopped plants the pods were well set and turning colour, but some flowers were still visible. The topped plants had sent out more secondary shoots and flowers. Some pods even could be found.

On 3rd February, or ninty-five days after transplanting.—On the untopped plants all the heads were ripe. The topped plants contained numerous heads, many of which were mature.

Treatment after Cutting.

Immediately after the plants were cut they were weighed and then hung on lines stretched across the laboratory, with a free access of both air and light, and remained there till thoroughly dry in the stalk. The first plants were only taken down towards the latter part of May.

During the period of drying, the plants were regularly examined. The untopped plants continued seed production or the ripening of the immature seeds. The extremities of the plants hanging downwards turned upwards, and for about three weeks afterwards pods continued to develop slowly in both topped and untopped plants. Even when the leaves at the base of the plant had dried off, development of the seed was still taking place.

Analysis of the Plants.

When the plants taken for analysis were thoroughly dry they were divided into their component parts, viz., leaf, stalk, and pod, as previously described. These were ground up in a hand-mill, well mixed, and the nicotine determined by the silico-tungstic acid method. Over 800 determinations in this laboratory have left the assurance that this method leaves nothing to be desired in speed and accuracy, a battery of half a dozen distillation apparatus allowing of as many determinations in a day as two workers can handle conveniently and with an accuracy far beyond the requirements of the investigation.

The percentages of nicotine in leaves, stalks, and pods are given in Table 9; the percentage of leaves, stalks, and pods on the whole plant in Table 10; and the green weights, air-dry weights, percentage of nicotine in the air-dry plant, and the nicotine in pounds per acre are all given in Table 11.

Discussion of Results.

In the survey of the tables it is impossible to make comparisons of the results of each cutting, and it is necessary in order to obtain a comprehensive view of the results, to consider the columns embracing each treatment separately and to make comparisons of the whole mass of data.

The Effects of Topping.—It appears that topping increases the green and dry weights per acre of the whole plant, and also increases the nicotine-content of the leaf and consequently the weight of nicotine per acre. These increases obtain for both fertilized and unfertilized plots. The effect of topping is not as striking as was expected. Considering, however, the rapid development of new tops—within a week after the first were removed—it is plain that two toppings in six weeks were not sufficient to check the development of enough pods to counterbalance the effect of the two toppings nearly completely. It is recommended that topping be done with a view to suppressing the entire development of the floral parts if the maximum benefits are desired, i.e. as frequently as possible. For the particular conditions under which this experiment

Table 9.—The Nicotine-content of leaves, stalks, and pods from the plots des

Time when Cut.	Number of Plot	1.	2.	3.	4.	5.
	Fertilizer Treatment	Control.	Nitrate of Soda.	Nitrate of Soda.	Control.	Sulphate of Ammonia.
	Treatment of Plants	Topped.	Topped.	—	—	Topped.
53 Days after Planting.	Per cent. nicotine in leaves	4·29	4·57	3·32	2·24	3·81
	Per cent. nicotine in stalks	1·07	0·81	0·91	0·94	1·01
	Per cent. nicotine in pods	Average for topped rows equalled 0·27. Average for untopped rows equalled 0·30.				
61 Days after Planting.	Per cent nicotine in leaves	3·70	4·21	3·69	3·38	4·76
	Per cent. nicotine in stalks	1·03	0·87	0·72	0·83	1·22
	Per cent. nicotine in pods	Average for topped rows equalled 0·38. Average for untopped rows equalled 0·37.				
68 Days after Planting.	Per cent. nicotine in leaves	4·94	5·14	5·56	4·64	6·65
	Per cent. nicotine in stalks	1·22	0·98	0·82	1·21	1·32
	Per cent. nicotine in pods	0·47	0·58	0·49	0·69	0·51
80 Days after Planting.	Per cent. nicotine in leaves	6·49	6·45	6·85	5·40	7·83
	Per cent. nicotine in stalks	1·01	1·12	1·14	1·25	1·10
	Per cent. nicotine in pods	0·78	0·69	0·91	0·87	0·42
87 Days after Planting.	Per cent. nicotine in leaves	7·63	7·26	7·18	6·71	7·35
	Per cent. nicotine in stalks	1·01	1·11	1·22	1·01	1·07
	Per cent. nicotine in pods	Average for topped rows equalled 0·47. Average for untopped rows equalled 0·91.				
95 Days after Planting.	Per cent nicotine in leaves	4·47	4·24	3·86	4·36	5·03
	Per cent. nicotine in stalks	0·97	0·84	0·92	1·00	0·89
	Per cent. nicotine in pods	Average for topped rows equalled 0·61. Average for untopped rows equalled 1·18.				

was carried out, it is obviously better to top the plants than to apply fertilizer without doing any topping, and this will probably be true in the majority of cases for plants grown on a rich or fertile soil.

The Effects of the Fertilizer Treatment.—The fertilized plots, on the whole, gave a slightly greater amount of nicotine than that obtained from the control plots—the differences are small and probably not significant. In practically every case the application of nitrogen seemed to have hastened the maturity of the plant. This is contrary to general experience.

It appears, from the results obtained in the experiment described in Section II, Part B, that the soil type on which the experiments were conducted stands in greater need of phosphates or potash, or both, than of nitrogen.

Experiments such as this just described emphasize the extreme care which must be exercised in interpreting the results obtained from fertilizer investigations.

PART B.

THE EFFECT OF COMPLETE FERTILIZER ON THE NICOTINE-CONTENT OF *N. RUSTICA*.

It was thought that the results of a mixed fertilizer treatment would be of interest as showing the effect of the addition of phosphate and potash to the nitrogen, as detailed in the previous section.

To this end a series of experiments was conducted by Hall, Research Chemist of this station, on soil of a similar nature and origin to that on which the experiments detailed in Section II, Part A, were carried out, the soil in this case being somewhat lighter.

The plants were harvested somewhat earlier than would have been desired, as the second cutting had hardly reached the stage of ripeness, showing the maximum of nicotine-content, and very probably a later cutting would have given higher yields of nicotine and green and, consequently, dry matter per acre.

The fertilizer treatment and the cultural treatment of the plants were as given below.

20th–22nd October. The ground was fertilized with the following mixture at the rate of 460 lb. per acre :—

10 parts of superphosphate.
8 parts of equal mixture of bonemeal and dust.
3 parts of sulphate of potash.
172·5 lb. of nitrate of lime.

This was applied in the rows and was washed in by a gentle shower during the night.

23rd October.—The plants were put out and 345 lb. of the following mixture were applied :—

6 parts of nitrate of lime.
6 parts of sulphate of ammonia.
3 parts sulphate of potash.
2·5 parts of superphosphate and lime in equal mixture.

The plants were topped on 12th December and again on 24th December, and were cut firstly on 2nd January and secondly on 9th January, being seventy and seventy-eight days respectively after planting. The weather conditions were as described in Section II, Part A, of this paper.

The fertilizer treatment conveyed to the soil the following ingredients per acre :—

Phospheric oxide (P_2O_5)—	Water soluble	41·8	lb.
	Citric soluble	48·2	,,
	TOTAL	52·6	,,
Nitrogen		45·0	,,
Potash (K_2O)		16·0	,,

The results of this test are detailed in Table 12, a survey of which shows that decided benefits were obtained as the result of the use of these mixtures. There were increases in the yields of green matter, leaves, etc., per acre, and this naturally produced a significant increase in the weights of nicotine obtained per acre as compared with those of the control plots. The treatment probably enforced earlier maturity.

SUMMARY AND CONCLUSIONS.

The general prospects of cultivating *N. rustica* as a commercial source of nicotine have been investigated. The tobacco plants used were derived from different areas in the Transvaal and the Cape Province, and the results, as far as they go, should thus give a fair idea of the situation.

Under favourable conditions, as many as three crops can be taken from the same plants, each crop yielding from 1,000 to 4,000 lb. of material (containing about 7 per cent. moisture) per acre. The moisture-content of the dry material will depend upon the humidity of the atmosphere, and must thus be taken into account in assizing the value or weight of a crop per acre.

The nicotine-content of the crop will depend chiefly upon the percentage of leaf present and the frequency of topping, although the judicious use of fertilizers will undoubtedly be an important factor in many localities.

Analyses of the entire plants showed a nicotine-content of 2·79 to 4·79 per cent. for plants grown at Potchefstroom and Rustenburg, and 1·64 to 1·78 per cent. for plants grown in the Cape Province, although much higher percentages are readily obtainable in this Province. On the whole, 4 per cent. may be taken as a fair average for plants grown under normal conditions of rainfall, soil, cultivation, etc.

The leaf contains the greater part of the nicotine present in the plant, the average amount being in the neighbourhood of 7 per cent. The stalk contains about 1 per cent. and the pods still less. Several batches of seed gave approximately 0·05 per cent. and roots in the neighbourhood of ½ per cent. of nicotine. Attempts should therefore be made to increase the percentage of leaf produced by the plant, as well as the percentage of nicotine in the leaf. Crossing *N. rustica* with *N. tabacum* has been attempted, but it is uncertain whether this is going to be successful. Owing to the great variation in the nicotine-content of different plants, breeding up by a process of selection seems to be the most promising.

Table 12.—Results of the experiment with a complete fertilizer described in Section II, Part B.

Fertilizer Treatment	Control.	Fertilized.	Control.	Fertilized.	Control.	Fertilized.	Control.
Per cent. nicotine in leaf	4·98	5·89	5·31	5·26	5·44	5·61	5·47
Per cent. nicotine in stalks	0·95	1·15	0·91	1·12	0·94	1·10	1·18
Per cent. nicotine in pods	1·19	1·03	0·88	0·95	0·86	0·91	1·00
Green weight per acre ... lb.	25,404	28,229	25,641	26,996	25,802	26,242	23,849
Air-dry weight per acre ... lb.	3,788	4,206	3,764	3,995	3,798	3,778	3,546
Per cent. air-dry matter in plant	14·91	14·90	14·68	14·80	14·72	14·40	14·87
Per cent. leaf in plant	44·4	50·0	41·2	50·0	44·0	47·0	47·0
Per cent. stalk in plant	24·4	32·7	30·0	28·3	29·0	27·5	28·2
Per cent. pod in plant	31·2	17·3	28·8	21·7	27·0	35·5	34·8
Per cent nicotine in plant	2·81	3·49	2·67	3·32	2·89	3·25	3·25
Weight of nicotine per acre ... lb.	106·5	146·8	100·5	132·0	109·7	122·8	115·2
Per cent. nicotine in leaves	6·71	6·21	5·90	6·44	6·40	7·01	6·32
Per cent. nicotine in stalks	1·00	0·96	1·12	0·83	1·23	0·96	1·10
Per cent. nicotine in pods	0·91	1·21	1·0	1·19	0·96	1·21	0·88
Green weight per acre ... lb.	29,120	34,407	28,197	32,847	30,021	32,423	28,721
Air-dry weight per acre ... lb.	4,455	5,202	4,342	5,038	4,368	4,928	4,314
Per cent. air-dry matter in plant	15·3	15·12	15·4	15·34	14·89	15·20	15·02
Per cent. leaf in plant	46·8	51·0	43·6	50·0	45·1	49·7	44·4
Per cent. stalk in plant	34·4	28·2	28·0	25·8	30·1	30·6	25·7
Per cent. pod in plant	29·8	20·8	28·4	24·2	24·8	19·7	29·9
Per cent. nicotine in plant	3·75	3·67	3·16	3·72	3·48	4·0	3·34
Weight of nicotine per acre ... lb.	167·0	190·0	137·2	187·4	152·0	197·1	144·0

The nicotine-content of the leaf increases as the plant matures up to a certain stage, after which it decreases rapidly. The stage at which the maximum amount of nicotine is présent can be determined readily and is obviously the period when the crop should be harvested.

Of the cultural treatments which may be applied to increase the yield of nicotine, "topping" has given the best results in the present investigation. Seed formation is a veritable drain on the plant and on the nicotine in the plant. This should, therefore, be prevented as much as possible, if not entirely, by removing the floral parts as soon as these are found. Not only is the nicotine thus conserved, but new leaf and, to some extent, new nicotine formation induced.

No marked benefits either in the percentage of nicotine per plant or in the total nicotine yield per acre were obtained by heavy applications of nitrogenous fertilizers, and marked benefits from applications of complete fertilizers in trials at Potchefstroom. On a poorer soil than that which obtains at Potchefstroom, however, the rational use of fertilizers will undoubtedly increase both the nicotine per plant and the total yield of material per acre.

The method of curing is of direct importance. The plant should be killed as soon as possible after cutting. For this purpose flue curing is the most effective and green curing nearly as good. Considering the expense involved in flue curing, green curing will probably be the most economical.

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